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㉒ Binder for metal-containing ores.

㉓ A binder composition useful for agglomerating an ore in the presence of water, that contains about 10% to about 90% of a water-soluble cellulose derivative and about 5% to about 90% of sodium tripolyphosphate or tetrasodium pyrophosphate, and a process for agglomerating an ore comprising mixing said binder composition, water, and the ore, agglomerating the mixture into wet balls, drying the wet balls, and heating the resultant dry balls at a temperature of at least about 1204 °C, are disclosed.

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## BINDER FOR METAL-CONTAINING ORES

This invention is directed to a binder for agglomerating concentrated ore, in particular, iron-containing ore also containing a water-soluble cellulose derivative, to a process for agglomerating concentrated ore using the binder, and to the agglomerated product of the process.

Raw or pig iron, used for making steel, is generally prepared by sintering a composition consisting of concentrated iron ore, consisting of iron oxide and residual silica (e.g., quartz), flux (e.g., limestone or dolomite), and coke. The flux is added to purge impurities, i.e., neutralize the silica. Slag, which results from this neutralization process, separates from the molten iron in the blast furnace. There is presently a desire to increase the efficiency of blast furnaces by reducing the volume of slag. Correspondingly, it is desired to reduce the cost of steel by reducing the amount of flux necessary for producing pig iron, i.e., by reducing the amount of silica entering the blast furnace.

The concentrated iron ore used in steel making is obtained from mined ores comprised of "host rock", i.e., rock comprised of silica and iron oxide. In order to reduce shipping and handling costs iron oxide is normally separated from the host rock at or near the mine by, for example, magnetic and/or froth flotation processes. Many ores, in particular the taconite ore found in North America, require ultra-fine grinding prior to carrying out such separation processes. Because of this grinding the concentrated ore is a fine powder which cannot be easily handled, shipped, or charged into a blast furnace. Therefore, the concentrated ore is agglomerated into porous particles or pellets generally having an average diameter of approximately 3/8 inch by rotating the concentrated ore powder in a drum or disc with a binder and water to form balls, followed by firing the balls at about 1316°C (2400°F) in an indurating furnace. The resulting particles or pellets are hard and are easily handled, shipped, and charged to a blast furnace.

Until recently, bentonite clay was the preferred binder for agglomerating concentrated ore particles; it provides moisture and growth control, and balls prepared with bentonite have very good wet and dry strength. But one problem with bentonite is that it contains a large amount of silica, which must be neutralized in the blast furnace, by adding additional amounts of flux. Accordingly, efforts have been made to replace bentonite with a product that has the beneficial attributes of bentonite without contributing silica. So-called "organic based binders", such as carboxymethylcellulose, have been considered as replacements for bentonite; since they do not contain silica they do not require use of additional flux, they burn off during sintering, and they increase the ratio of surface area to mass of the concentrated ore-containing pellet.

Also, the reduction of the pellets produced using organic binders is much more efficient because of their larger surface area. The rate of reduction of iron oxide to the metallic state in the blast furnace by reducing gases, such as carbon monoxide, is directly proportional to that surface-to-mass ratio, in other words, to the pore volume. During sintering, bentonite fuses to a glass-like ceramic material that seals pores, while the pore volume of pellets produced using organic binders increases as the organic binder burns off.

European Patent Application 0203855 describes a method for agglomerating a particulate material such as mineral ore concentrate comprising mixing the particulate material with a binding amount of water-soluble, ore binding polymer and clay. The polymers include carboxymethylcellulose, guar gum, hydroxyethylcellulose, poly(ethylene oxide) and polyacrylic acid. U.S. Patents 4,288,245 and 4,597,797 suggest that the binding performance of alkali metal salts of carboxymethylcellulose can be improved by inclusion of at least 2% of a salt of an alkali metal and a weak acid having a pH value higher than 3 and a molecular weight lower than 500, such as salts of acetic acid, benzoic acid, lactic acid, propionic acid, tartaric acid, succinic acid, citric acid, nitrous acid, boric acid and carbonic acid. One such binder is marketed under the name Peridur® and is believed to contain the sodium salt of carboxymethylcellulose, sodium carbonate, and side-products from the formation of the carboxymethylcellulose salts, including sodium chloride and sodium glycolate.

However, such known water-soluble cellulose derivatives, though possibly acting as effective binders, do not impart adequate wet and dry strength to agglomerated ore material at levels of use that are economical.

According to the invention, the dry-strength performance of processes using water-soluble cellulose derivatives for agglomerating a metal-containing ore material in the presence of water, is greatly enhanced by a composition containing a water-soluble cellulose derivative, that is characterized in that it also contains about 5% to about 90% of sodium tripolyphosphate or tetrasodium pyrophosphate, the amount of the cellulose derivative being about 10% to about 90%, the said percentages being by total dry weight of the binder composition according to the invention.

Also according to the invention, a process for agglomerating an ore comprising mixing a binder

composition containing a water-soluble cellulose derivative, water, and concentrated ore, agglomerating the mixture into wet balls, drying the wet balls, and heating the resultant dry balls at a temperature of at least about 1204°C, is characterized in that the the binder composition is the binder composition according to the invention in an amount of at about 0.0022% by weight of the total dry mixture.

5      Sodium tripolyphosphate is a powder or granular salt having the formula  $\text{Na}_5\text{P}_3\text{O}_{10}$  prepared by evaporating a saturated orthophosphate solution and calcining at 500°C. It is commercially available from FMC Corporation of Philadelphia, Pennsylvania under its generic name. Commercially available products generally contain minor amounts of impurities, e.g., disodium pyrophosphate and tetrasodium pyrophosphate.

10     Tetrasodium pyrophosphate is a powder or granular salt having the formula  $\text{Na}_4\text{P}_2\text{O}_7$ . It is commercially available from FMC Corporation of Philadelphia, Pennsylvania.

Since the amount of the binder composition according to the invention relative to the amounts of water and concentrated ore used in the process are conventionally dependent on the specific agglomeration method used, the nature of the ore material to be agglomerated and the desired properties of the agglomerates to be prepared, a person of ordinary skill in the art can readily determine the specific ingredient levels and amounts of the binder composition, above the minimum limits that will be most suitable for individual circumstances. Preferably the pelletization is carried out using the binder composition in an amount of from about 0.0022% to about 0.44% by weight of the total dry mixture, preferably from about 0.033% to about 0.066%, and using enough water for adequate hydration, about 5% to about 15%, more preferably about 8.5% to about 10%, by weight of the total dry mixture.

In addition, clays such as bentonite clay optionally may be used in pelletization. The total amount of these clays will depend on the user's objectives, but will generally be less than 0.22%, based on the weight of the total dry mixture. Since silica, the major components of such clays, is detrimental to blast furnace operation, binders with substantially no clay are preferred.

25     Within the limits of about 10% to about 90% for the water-soluble cellulose derivative, it is preferred to use about 30% to about 70%, and within the limits of about 5% to about 90% for the polyphosphate salts, it is preferred to use about 30% to about 70%, all by total dry weight of the binder composition.

Any conventional method for forming dry pellets or particles can be used to prepare the agglomerates of this invention. For instance, the concentrated ore may be agglomerated into particles or pellets by 30 rotating the concentrated ore powder in a drum or disc with a binder and water, followed by drying and firing. Pellets can also be formed by briquetting, nodulizing, or spray drying.

Also, the addition of the binder composition constituents may be carried out conventionally. For instance, the binder constituents may be mixed as solid matter with the concentrated ore or while dissolved in water. Further, they may be simultaneously, successively or alternatively added to the concentrated ore 35 before or during the pelletizing treatment. In a preferred method the binder composition is added to a moist concentrated ore resulting from the aforementioned separation process, which has all but about 10 wt. % of the water removed by, e.g., rotating disc filter, at a sufficient point upstream from the agglomerating drum or disc so that the binder components and concentrated ore are well mixed and adequately hydrated prior to being formed into balls.

40     Any water-soluble cellulose derivatives can be used in the composition according to the invention. The preferred ones are alkali and alkaline earth metal salts of carboxymethylcellulose, hydroxyethylcellulose, hydroxypropylcellulose and alkali and alkaline earth metal salts of carboxymethyl hydroxyethylcellulose. More preferred are the alkali metal salts of carboxymethylcellulose and carboxycarboxymethyl hydroxyethylcellulose, the most preferred being sodium carboxymethylcellulose.

45     Any substantially water-soluble metal salt of carboxymethylcellulose may be used in the preferred embodiments of this invention. Such metal salts, more particularly sodium carboxymethylcellulose, are conventionally prepared from alkali cellulose and the respective metal salt of monochloroacetic acid. The cellulose is usually derived from wood pulp or cotton linters, but may be derived from other sources such as sugar beet pulp, bagasse, rice hulls, bran, microbially-derived cellulose, and waste cellulose (e.g., 50 shredded paper).

Sodium carboxymethylcellulose used in this invention generally has a degree of substitution (the average number of carboxymethyl ether groups per repeating anhydroglucose chain unit of the cellulose molecule) of from about 0.4 to about 1.5, more preferably about 0.6 to about 0.9, and most preferably about 0.7. Generally the average degree of polymerization of the cellulose furnish is from about 300 to about 55 4000. Polymers having a degree of polymerization on the higher end of the range are preferred. However, best results are obtained with sodium carboxymethylcellulose having a Brookfield viscosity in a 1% aqueous solution of less than about 4,000 cps at 20 rpm. These parameters are well known, as well as the equivalent ones for sodium carboxymethyl hydroxyethylcellulose, for instance from the standard text by G.

I. Stelzer and E. D. Klug, "Carboxymethylcellulose", in the Handbook of Water-Soluble Gums and Resins, Chapter 4, (R. L. Davidson, Ed.; 1980). Carboxymethylcellulose is commercially available from Aqualon Company, Wilmington, Delaware. Carboxymethyl hydroxyethylcellulose is also a well known water-soluble polymer, commercially available from the same source.

5 Conventionally-sized water-soluble polymer particles perform well in this invention. However, due to the small percentage of binder used, fine particle size polymers tend to perform better than the equivalent regular particle size materials. Therefore, in some instances it is preferable to grind the polymer before its use. One preferred polymer is Aqualon<sup>TM</sup> CMC 7HX (Aqualon Company, Wilmington, Delaware), which has a particle size such that 80 weight % passes through a U.S. 200 mesh screen.

10 The binder composition may also contain (as well as the water-soluble cellulose derivatives and the phosphates), substances that are formed as by-products in the preparation of the cellulose derivatives, such as sodium chloride and sodium glycolate (which are often present as impurities in carboxymethylcellulose), as well as polysaccharides and synthetic water-soluble polymers. The polysaccharide by-products may include hydroxyethylcellulose, hydroxypropylcellulose, methyl cellulose, hydroxypropyl methyl cellulose, 15 guar, hydroxypropyl guar and sugar beet pulp, and the synthetic water-soluble polymers may include polyacrylamide, polyvinyl alcohol, styrene/maleic anhydride copolymers, and polyacrylate, and inorganic salts such as alkali carbonates, citrates, acetates, benzoates, propionates, succinates, etc. (for instance, the salts described referred to in U.S. Patent Nos. 4,288,245 and 4,597,797).

20 Small amounts of flux, e.g., limestone or dolomite, may also be added to enhance dry strength. The flux also helps to reduce the dust level in the indurating furnace when the balls are fired. Olivine, serpentine and similar minerals may be used to improve fired pellet properties.

25 Drying the wet balls and firing the resultant dry balls may be carried out as one continuous or two separate steps. The important factor is that the balls must be dry prior to firing as the balls will degrade or spall if fired without first drying them. Thus, in one embodiment of this invention, the wet balls are heated slowly to a temperature of at least about 1204 °C (2200 °F), preferably to at least about 1316 °C (2400 °F), and then fired at that temperature. In another embodiment, they are dried at low temperatures, preferably by heating, or, alternatively, under ambient conditions, and then fired at a temperature of at least about 1204 °C, more preferably at about 1316 °C. Firing is carried out for a sufficient period of time to bond the small particles into pellets, generally about 15 minutes to about 3 hours.

30 The process of this invention is generally employed with concentrated iron ore. This process is also suitable for non-ferrous concentrated ores such as ores of zinc, lead, tin, nickel and chromium and oxidic materials such as silicates and quartz, and sulphidic materials. As a practical matter, this invention is intended for use in binding the concentrated ores that result from separation of the host rock from the ore removed from the ground. However, it can also be used to bind natural ores.

35 The pellets resulting from this process are dry, hard agglomerates having sizes that are suitable for shipping, handling, sintering, etc. Pellets generally have an average diameter of about 0.64 cm to 1.9cm (1/4 to about 3/4 in), preferably about 0.95 cm (3/8 in). The pellet size generally depends on the preference of the user or operator, more than on any variation in the binding ability of the compositions of the invention; virtually any sizes of pellets desired by blast furnace operators and mine operators can be 40 prepared.

This invention is illustrated in the following examples, wherein all parts, percentages, etc., are by weight unless otherwise indicated.

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#### Example 1

This example is directed to preparation and testing of wet and dry balls prepared using the binder of this invention.

50 The ore used was a magnetic taconite concentrate containing approximately 65 wt. % iron and approximately 4.6 wt. % silica obtained from a U.S. operation. In a Hobart model N-50 oscillating mixer, 3240 g of the ore, having a moisture content of 7.4%, was mixed with additional water (distilled) to obtain the desired moisture level. The chosen quantity of dry binder blend was then sprinkled onto the surface of the moist ore and mixing was continued for 3 minutes. Next, the ore/binder mix was passed one time 55 through a high speed shredder to make a uniform, clump free blend suitable for balling.

Balls were made in a 15 inch diameter (size 6.00-6) airplane tire, rotated at a rate of 65 revolutions per minute with the axis of rotation being horizontal, as follows:

1. Small amounts of ore were fed by hand into the rotating tire alternately with distilled water mist. As seed balls formed they were removed and hand screened to -4.75, +4mm. A portion (800 g) of ore was set aside for seed preparation. This process was continued until at least 100 g of seed balls were generated.
2. Ninety-two (92) g of prepared seed balls were put in the rotating tire and moistened slightly with a fine mist spray of distilled water. Part of the remaining 2440 g of ore was added to the seeds as quickly as possible over a 1 minute period. The balls were removed and the newly formed seeds (-4.75mm) were screened out and discarded.
3. The +4.75mm balls were returned to the rotating tire and the remainder of the ore was added over a 1-1 1/2 minute time period. The finished balls were then rolled for 5 seconds.
4. The wet balls were screened to determine size distribution. A -12.7, +11.2mm cut was used to determine moisture content.

Two standard tests were used to measure performance, i.e., the drop test and the compressive strength test. The drop test and compressive strength test demonstrate the ability of wet and dry balls to withstand cracking under normal handling conditions. Balls must have sufficient prefired strength so that they do not crack during handling or transfer in the pellet plant, but must not be so plastic that they deform and impair bed permeability in the indurating furnace.

The drop test carried out by dropping the wet balls repeatedly from a height of 56.1 cm (18 in) onto a smooth steel plate. The number of drops required to crack a ball was recorded and the average value for 10 balls reported.

- 5 20 Compressive strength was measured by applying pressure to both wet and dry pellets until the pellets crumbled. The apparatus consisted of a Chatillon Model No. LTCM-3 spring testing device (manufactured by John Chatillon Company, New York, New York) with appropriate range dial push-pull gauge (2.27 kg (5 lb) capacity for wet, 11.35 kg (25 lb) for dry). Dried balls were obtained by placing green balls in a 105°C oven for 18 hours. Average wet ball moisture was determined by comparing the weight of balls before and after drying. Compressive strength results presented are also the average of 10 balls tested.

The formulations used and results obtained are shown in the following Table.

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Table 1

Poly- saccharide(s) <sup>1</sup> (#)	STPP <sup>2</sup> (%)	Drop Number	Wet Compr. (kg)	Dry Compr. (kg)	Ball Moisture (%)
1-1 0.033 CMC 7HX <sup>3</sup>	0.033	4.1	.78	4.8	0.0
1-2 0.033 CMC 7HX	0.033	11.2	1.3	6.0	8.9
1-3 0.033 CMC 7HX	0.033	14.9	1.4	6.3	9.8
1-4 0.033 CMC 7HX <sup>4</sup>	0.033	6.0	1.4	4.9	9.3
1-5 0.033 CMC 7HX <sup>5</sup>	0.033	9.1	1.5	6.5	9.2
1-6 0.033 CMC 7HX	0.033	15.8	1.5	7.2	9.5
1-7 0.064 CMC 7HX	0.003	13.8	1.3	5.1	9.2
1-8 0.030 CMC 7HX	0.037	16.3	1.5	6.4	9.2
1-9 0.010 CMC 7HX	0.057	5.6	1.3	5.3	9.2
1-10 0.011 CMC 7HX	0.011	3.1	1.0	1.5	8.8
1-11 0.033 CMC 7HX	0.033	11.2	1.4	4.6	9.0
1-12 0.067 CMC 7HX	0.067	17.3	1.5	7.9	9.8
1-13 0.022 CMC 7HX	0.022	10.1	1.4	4.8	9.5
1-14 0.022 SBP <sup>6</sup>	-	-	-	-	-

1. Percentage is based on the total weight of the dry composition, including concentrated ore.
2. Sodium tripolyphosphate. Percentage is based on the total weight of the dry composition, including concentrated ore.
3. Sodium carboxymethylcellulose having a degree of polymerization of 3200, available from Aquafon Company, Wilmington, DE.
4. Sodium carboxymethylcellulose having a degree of polymerization of 400, available from Aquafon Company, Wilmington, DE.
5. Sodium carboxymethylcellulose having a degree of polymerization of 1100 available from Aquafon Company, Wilmington, DE.
6. Cellulose derivative produced from sugar beet pulp available from Petroleum Fluids Incorporated, Houston, Texas, under the name HP-007 having an apparent viscosity at 7 lbs./barrel in a 4% CaCl<sub>2</sub> solution of 18.5 cps.

Generally mine operators require that green balls be able to withstand at least 6 drops. Similarly, dry compressive strength of 4.54 kg (10 lb) or more is desired. In practice, however, it has been difficult to attain dry strengths of greater than 2.27 kg (5 lb) with non-bentonite binders at economically acceptable use levels.

Samples 1-1 through 1-3 demonstrate that the invention is effective over the range of ball moisture levels normally encountered at taconite production facilities. As can be seen, wet ball physical properties are improved by increasing moisture content. Also, dry ball strengths in excess of 4.54 kg (10 lb) are attained. These values are unusually high compared to other commercially available organic binders.

Samples 1-4 through 1-6 show that sodium carboxymethylcellulose having a wide range of molecular

weight has utility in this invention. Generally, higher molecular weight sodium carboxymethylcellulose imparts greater impact resistance to the wet ball formed. This effect is significantly less noticeable in the dry strength data where the sodium tripolyphosphate shows a considerable leveling effect.

Samples 1-7 through 1-9 show that the ratio of sodium carboxymethylcellulose to sodium tripolyphosphate can be varied widely for effective use as an iron ore binder. In addition, the results indicate that sodium tripolyphosphate itself does not give adequate drop number to be considered an effective binder. The best overall performance occurred when the sodium carboxymethylcellulose and sodium tripolyphosphate were present in nearly equal quantities.

Samples 1-10 through 1-12 illustrate the effect of binder dosage. Generally, mine operators require that green balls withstand 6 drops. It is desirable to have as little phosphate as possible for best steel quality and lower cost. Therefore, the optimum dosage would occur with a dosage level between that of Samples 1-10 and 1-11.

Sample 1-13 shows that other polymers can be used as effective partial replacements for the carboxymethylcellulose of the invention.

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Example 2

20 This example compares binders of this invention with binders containing other phosphate salts. This example was carried out in the same manner as described in Example 1, except for the differences mentioned below.

The ore was from a different U.S. operation than that used in Example 1. It was a magnetic taconite concentrate containing approximately 65 wt.% iron and approximately 4.5 wt. % silica.

25 The ore placed in the Hobart mixer had a moisture content of 7.2%. Only 3234g was used (Note: as a result only 2434g of ore remained for addition to the seeds in step 2).

The binder formulations and amounts used, and the results obtained are shown in the following Table.

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Table 2

Sample	Polysaccharide(s) <sup>1</sup>	Salt	Dosage (kg/m <sup>2</sup> )	Wet Drop Number	Wet Compr. Strength (kg)	Dry Compr. Strength (kg)	Ball Moisture (%)
2-1	CMC 7HX <sup>3</sup>	Sodium Tripolyphosphate <sup>4</sup>	.447	10.4	1.4	4.2	9.3
2-2	CMC 7HX <sup>3</sup>	Tetrasodium Pyrophosphate <sup>5</sup>	.447	10.1	1.5	4.6	9.4
2-3	CMC 7HX <sup>3</sup>	Di ammonium Phosphate <sup>6</sup>	.447	3.5	1.4	2.8	9.1
2-4	CMC 7HX <sup>3</sup>	Disodium Phosphate <sup>4</sup>	.447	6.4	1.0	3.9	9.2
2-5	CMC 7HX <sup>1</sup>	Sodium Tetrametaphosphate <sup>4</sup> <sup>6</sup>	.447	7.2	1.3	4.1	9.5
2-6	CMC 7HX <sup>3</sup>	Sodium Hexametaphosphate <sup>4</sup> <sup>7</sup>	.447	7.9	1.2	3.6	9.2
2-7	CMC 7HX <sup>3</sup>	Potassium Phosphate MonoBasic <sup>4</sup>	.447	2.0	1.0	2.0	9.0

1. Percentage is based on the total weight of the dry composition, including concentrated ore.

2. Kg of binder composition per tonne of ore. All runs were conducted using a 1:1 ratio of polysaccharide to salt.

3. Aqualon<sup>TM</sup> CMC 7HX is sodium carboxymethylcellulose, available from Aqualon Company, Wilmington, DE.

4. Available from FMC Corporation, Philadelphia, Pennsylvania.

5. Available from Stauffer Chemical Co., Westport, Connecticut

6. [NaPO<sub>3</sub>]<sub>n</sub>, wherein n = 6.

7. [NaPO<sub>3</sub>]<sub>n</sub>, wherein n = 21.

Example 3

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This example was carried out in the same manner as Example 1. The control samples were carried out using Aqualon™ CMC 7HX (Aqualon Company, Wilmington, DE). In the other samples a 1:1 ratio of Aqualon™ CMC 7HX to salt was used. Results are shown in Table 3.

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Table 3

15	Sample	Salt	Dosage (kg/t <sup>1</sup> )	Wet Drop Number	Wet Compr. Strength (kg)	Dry Compr. Strength (kg)	Ball Moisture (%)
20	3-1	--	.34	6.6	1.1	.9	8.9
	3-2	--	.67	17.6	1.1	2.9	9.5
	3-3	Sodium Tripolyphosphate <sup>2</sup>	.67	10.1	1.6	3.3	9.2
	3-4	Sodium Tripolyphosphate <sup>2</sup>	.67	10.6	1.5	3.0	9.3
25	3-5	Sodium Carbonate	.67	6.9	1.4	3.1	9.3
	3-6	Calcium Carbonate	.67	5.4	1.2	0.78	9.1
	3-7	Na <sub>2</sub> SO <sub>4</sub>	.67	5.6	1.3	0.86	9.1
	3-8	Sodium Formate	.67	3.5	1.0	0.59	9.1
30	3-9	Sodium Benzoate	.67	3.6	1.2	0.82	9.1
	3-10	NaNO <sub>3</sub>	.67	3.7	1.0	0.73	9.1
	3-11	Sodium Nitrilotriacetate	.67	12.9	1.6	2.4	9.3
	3-12	Sodium Tetraborate	.67	6.6	1.4	1.4	9.5
	3-13	Sodium Citrate	.67	15.0	1.5	4.6	9.7
	3-14	Calcium Chloride	.67	3.4	0.90	0.36	8.8
	3-25	Sodium Chloride	.67	3.1	1.0	0.59	9.1
	3-16	Sodium Hexametaphosphate	.67	13.2	1.5	3.7	9.2

1. Kg of binder composition per tonne of ore.

2. Available from FMC Corporation, Philadelphia, Pennsylvania.

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Example 4

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The procedures of Example 3 were repeated using carboxymethyl hydroxyethylcellulose (Aqualon™ CMHEC 420H, available from Aqualon Company, Wilmington, DE). In each blend, a 1:1 ratio of CMHEC/salt was used. Results are shown in Table 4.

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Table 4

Sample	Salt	Dosage (kg/t <sup>1</sup> )	Wet Drop Number	Wet Compr. Strength (kg)	Dry Compr. Strength (kg)	Ball Moisture (%)
4-1	—	0.75	6.1	1.2	0.82	9.0
4-2	Sodium Tripolyphosphate	1.5	11.1	1.3	1.8	9.2
4-3	Sodium Carbonate	1.5	7.1	1.2	1.4	9.1
4-4	Calcium Carbonate	1.5	8.1	1.3	0.68	9.3
4-5	Na <sub>2</sub> SO <sub>4</sub>	1.5	6.9	1.4	0.68	9.2
4-6	Sodium Formate	1.5	5.3	1.3	0.82	9.2
4-7	Sodium Citrate	1.5	8.3	1.5	2.3	9.2

15 1. Kg of binder composition per tonne of ore.

20 Example 5

This example was carried out in the same manner as Example 1, using the polysaccharides and salts described in the following table. In each blend, the ratio of polysaccharide to salt was 1:1.

25 The ore used was from a third U.S. operation, and had an iron and silica concentration similar to that of the ore of Example 1.

The ore placed in the Hobart mixer had a moisture content of 8.1%.

In this example, 3264g of ore concentrate and 51g of distilled water was used to bring the initial moisture level to 9.5% (Note: as a result 2464g of ore concentrate was available for addition to the seeds in step 2).

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Table 5

<u>Sample</u>	<u>Polysaccharide</u>	<u>Salt</u>	<u>Dosage (kg/t<sub>1</sub>)</u>	<u>Wet Drop Number</u>	<u>Wet Compr. Strength (kg)</u>	<u>Dry Compr. Strength (kg)</u>	<u>Ball Moisture (%)</u>
5-1	Aqualon <sup>TM</sup> CMC 7HX <sup>2</sup>	--	1.0	9.1	1.1	2.7	9.2
5-2	Aqualon <sup>TM</sup> CMC 7HX	Sodium Tri-polyphosphate	1.0	6.7	1.3	2.5	9.1
5-3	Aqualon <sup>TM</sup> CMC 7HX	Sodium Tri-polyphosphate	2.0	10.7	1.1	4.7	9.2
5-4	Aqualon <sup>TM</sup> CMC 7HX	Sodium Tri-polyphosphate	2.0	11.5	1.1	4.1	9.2
5-5	Aqualon <sup>TM</sup> CMC 7HX	Sodium Hexa-metaphosphate	1.0	5.8	1.3	2.0	9.1
5-6	Aqualon <sup>TM</sup> CMC 7HX	Sodium Hexa-metaphosphate	2.0	11.0	1.1	4.8	9.2
5-7	Aqualon <sup>TM</sup> CMC 7HX	Sodium Hexa-metaphosphate	2.0	14.2	1.1	5.2	9.4

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Table 5 (cont'd)

Sample	Polysaccharide	Salt	Dosage (kg/t <sub>1</sub> )	Wet Drop Number	Wet Compr. Strength (kg)	Dry Compr. Strength (kg)	Ball Moisture (%)
5-8	Matrosol 250 HDKR	--	1.0	4.9	.78	1.8	9.2
5-9	Matrosol 250 HDKR	Sodium Tri- polyphosphate	2.0	9.3	1.23	1.2	9.1
5-10	Matrosol 250 HDK	--	1.0	8.6	1.3	1.8	9.1
5-11	Matrosol 250 HDK	Sodium Tri- polyphosphate	2.0	10.7	1.4	1.8	9.1
5-12	Matrosol 250 HDK	Sodium Tri- polyphosphate	2.0	7.8	1.1	1.8	9.1

Table 5 (cont'd)

Sample	Polysaccharide	Salt	Dosage (kg/t <sub>1</sub> )	Wet Drop Number	Wet Compr. Strength (kg)	Dry Compr. Strength (kg)	Bal.) Moisture (%)
5-13	Klucel HXF <sup>a</sup>	--	1.0	10.7	3.0	3.9	9.1
5-14	Klucel HXF	Sodium Tri- polyphosphate	2.0	6.4	2.3	3.8	9.1
5-15	Klucel HXF	Sodium Hexa- metaphosphate	2.0	8.3	1.9	2.8	9.1
5-16	Aqualon <sup>m</sup> CMHEC 420H <sup>s</sup>	--	1.0	6.6	2.0	2.5	9.1
5-17	Aqualon <sup>m</sup> CMIEC 420H	Sodium Tri- polyphosphate	2.0	8.6	2.8	4.7	9.1
5-18	Aqualon <sup>m</sup> CMIEC 420H	Sodium Hexa- metaphosphate	2.0	9.3	2.4	5.2	9.2

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Table 5 (cont'd)

Sample	Polysaccharide	Salt	Dosage (kg/t <sup>1</sup> )	Wet Drop Number	Wet Compr. Strength (kg)	Dry Compr. Strength (kg)	Ball Moisture (%)
5-19	Aqualon <sup>TM</sup> CGHEC 420H	Tetrasodium Pyrophosphate	2.0	10.1	2.5	6.1	9.1
5-20	Aqualon <sup>TM</sup> CGHEC 420H	Disodium Phosphate	2.0	10.9	3.1	4.8	9.2
5-21	CulminaL 12000P <sup>6</sup>	--	1.0	12.4	2.8	3.2	9.2
5-22	CulminaL 12000P	Sodium Tri- polyphosphate	2.0	12.5	2.9	4.1	9.3
5-23	Peridur XC-3 <sup>7</sup>	--	2.0	6.0	2.0	7.1	9.1

1. Kg of binder composition per tonne of ore.
2. Sodium Carboxymethylcellulose. Available from Aqualon Company, Wilmington, DE.
3. Hydroxyethylcellulose. Available from Aqualon Company, Wilmington, DE.
4. Hydroxypropylcellulose. Available from Aqualon Company, Wilmington, DE.
5. Carboxymethyl Hydroxyethyl Cellulose. Available from Aqualon Company, Wilmington, DE.
6. Methyl Cellulose. Available from Aqualon Company, Wilmington, DE and Aqualon Gah & Co. KG, Dusseldorf, Federal Republic of Germany.
7. A blend believed to comprise carboxymethylcellulose and sodium carbonate, available from Akzo NV, Arnhem, The Netherlands.

The data in Tables 3-5 shows that the binder of this invention performs very well as compared to other binders. Most notable is the strong performance of the binder of this invention at all levels and, particularly, at low levels (see, e.g., Example 5-2).

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### Claims

1. A binder composition that contains a water-soluble cellulose derivative, characterized in that it also contains about 5% to about 90% of sodium tripolyphosphate or tetrasodium pyrophosphate, the amount of the alkali metal salt of the cellulose derivative being from about 90% to about 10%, the said percentages being by total dry weight of the binder composition.
2. A binder composition as claimed in claim 1, further characterized in that it contains about 30% to about 70% of the cellulose derivative, and from about 70% to about 30% of the phosphate salt, by weight of the total composition.
3. A binder composition as claimed in claim 1 or 2, further characterized in that the phosphate salt is sodium tripolyphosphate.
4. A binder composition as claimed in any of the preceding claims, further characterized in that the cellulose derivative is an alkali metal salt of carboxymethylcellulose.
5. A binder composition as claimed in any of the preceding claims, further characterized in that the cellulose derivative is sodium carboxymethylcellulose.
6. A binder composition as claimed in claim 4, further characterized in that the sodium carboxymethylcellulose has a degree of substitution of about 0.4 to about 1.5.
7. A binder composition as claimed in any of the preceding claims, further characterized in that the cellulose derivative is formed from a cellulose furnish having an average degree of polymerization of 300 to 4000.
8. A process for agglomerating an ore comprising mixing a binder composition containing a water-soluble cellulose derivative, water, and the ore, agglomerating the mixture into wet balls, drying the wet balls, and heating the resultant dry balls at a temperature of at least about 1204 °C, is characterized in that the binder composition is the binder composition as claimed in any of the preceding claims.
9. A process for agglomerating an ore material as claimed in claim 8, further characterized in that the ore is concentrated iron ore.
10. A process for agglomerating a concentrated ore material as claimed in claim 9, further characterized in that the mixture contains at least about 0.022% of the binder composition and at least about 5% water by weight of the dry mixture.
11. A process for agglomerating a concentrated ore material as claimed in claim 10, further characterized in that the mixture contains up to about 0.22% of the binder composition and up to about 15% water by weight of the dry mixture.
12. A process for agglomerating a concentrated ore material as claimed in claim 10, further characterized in that the cellulose derivative is sodium carboxymethylcellulose and the mixture contains from 0.033% to 0.66% of the binder composition and from 8.5% to 10% water by weight of the dry mixture.

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X, D	EP-A-0 203 855 (UNION CARBIDE CORP.) * Claims 1,5; pages 6,8 * ---	1-12	C 22 B 1/242 C 22 B 1/244
P, X	CHEMICAL ABSTRACTS, vol. 108, 1988, page 257, abstract no. 135852y, Columbus, Ohio, US; & SU-A-1 359 052 (CHEBOKSARY ASSEMBLY PLANT) 15-12-1987 * Abstract * ---	1,3	
A	FR-A-2 102 124 (CATOLEUM PROPRIETARY LTD) ---		
A	AU-A- 26 178 (C.W. HUMPHREY) ---		
A	US-A-3 376 145 (W.K. WALLACE) ---		
A	US-A-4 597 797 (H.J. ROORDA) ---		
A	CHEMICAL ABSTRACTS, vol. 97, 1982, page 253, abstract no. 76314d, Columbus, Ohio, US; L. CHUANLIN: "Separating copper-lead concentrates by flotation with sodium pyrophosphate" & YOUSE JINSHU 1982, 34(1),38-42 ---		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
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The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	09-08-1988	JACOBS J.J.E.G.	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	
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